N. Shikazono LAB.

[Solid Oxide Fuel Cell and Next Generation Heat Engines]

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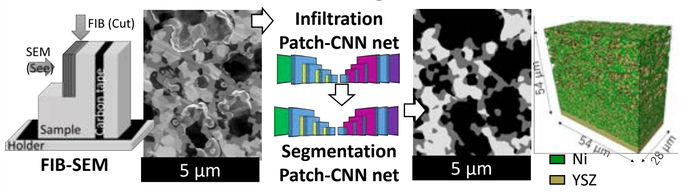
Polarization Characteristics and Microstructures of Solid Oxide Fuel Cell Electrodes

Electrode microstructures strongly affect the polarization characteristics of solid oxide fuel cells (SOFCs). Machine learning, e.g. CNN and CGAN as well as large-scale numerical simulations such as lattice Boltzmann, phase field, kinetic Monte Carlo and discrete element methods are developed to optimize the whole lifetime characteristics of the electrodes from initial powder to long time operation. Three dimensional microstructures reconstruction by FIB-SEM and in operando observations play inevitable role for understanding the phenomena and model validation.

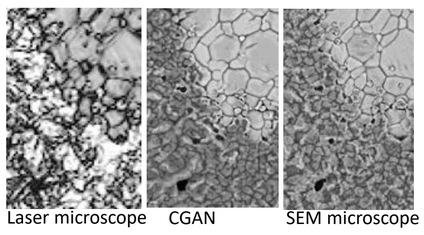
Machine learning in SOFC study

ML-supported microstructure analysis

Microstructure segmentation



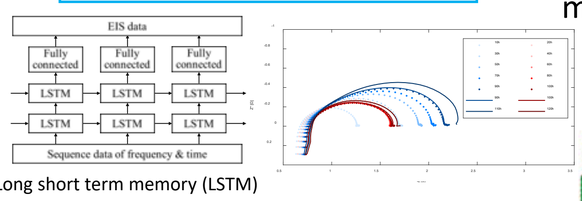
CGAN super resolution



FIB-SEM reconstruction without resin infiltration

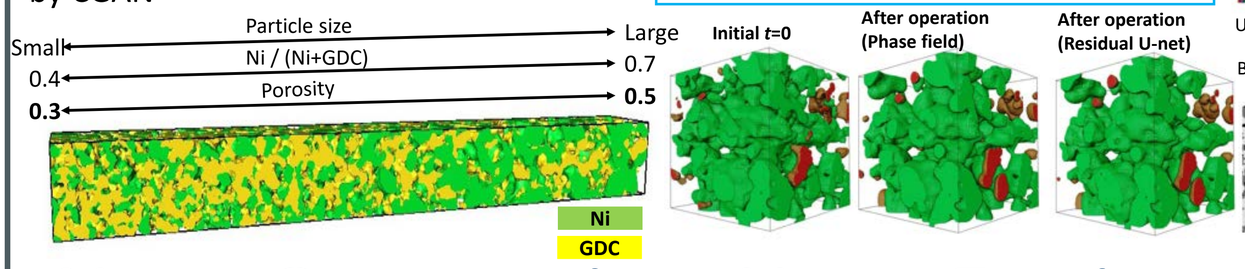
3D synthetic microstructure generation by CGAN

Degradation prediction

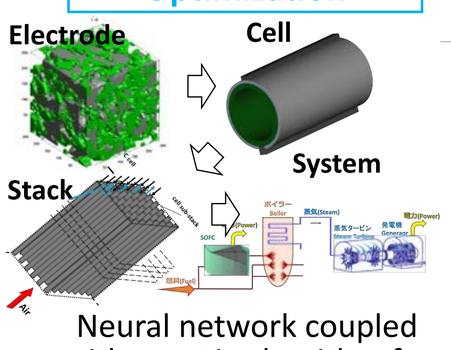


Long short term memory (LSTM)

Long-time degradation prediction

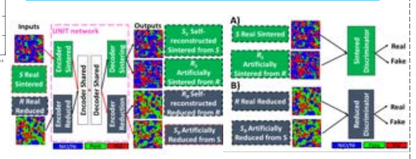


Optimization

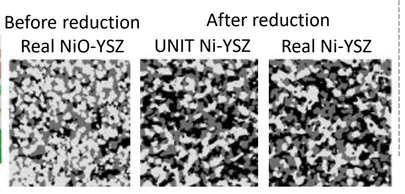


Neural network coupled with genetic algorithm for multi-objective optimization

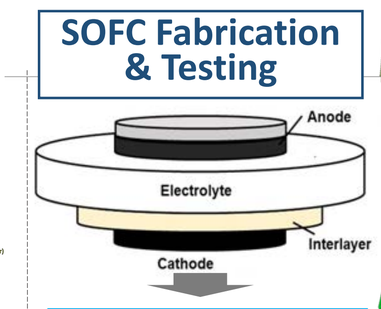
Reaction prediction



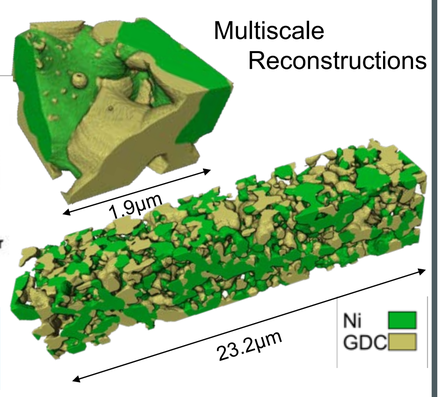
Unsupervised image-to-image translation (UNIT)



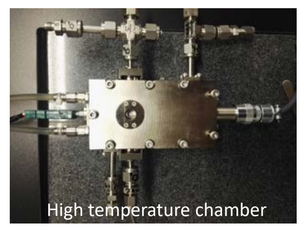
SOFC Fabrication & Testing

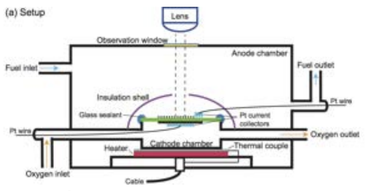


Microstructure Evaluation

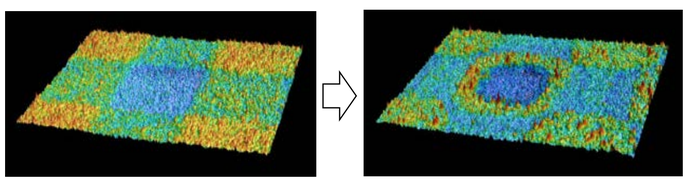


Quantitative characterization of electrode microstructures using focused ion beam scanning electron microscope (FIB-SEM).





850℃, $V_{A\text{-}C}$=0.5 V
H_2:N_2:H_2O = 10:87:3 %, O_2 = 100%



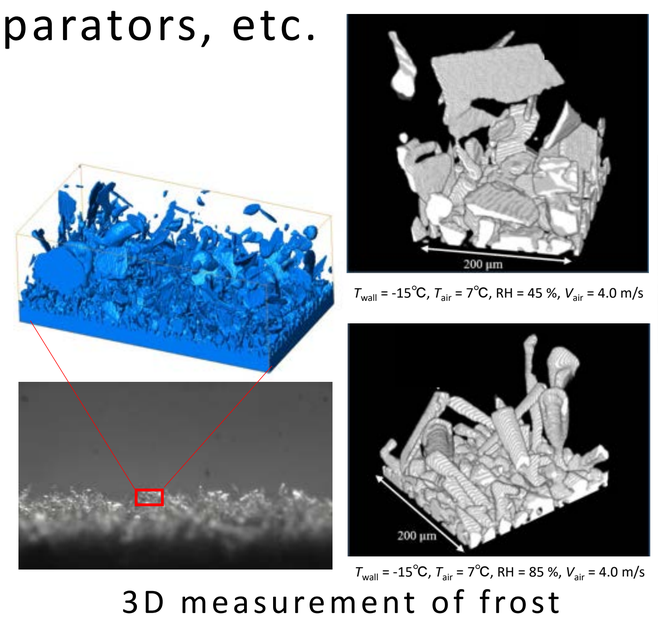
Operando observation of patterned Ni-GDC anode.

Next Generation Heat Engines

Efficient utilization of thermal energy will become even more important in the future energy systems. In order to reduce exergy loss, heat cycles which operate at small temperature difference, and component technologies such as efficient heat exchangers and gas-liquid separators are developed under collaboration with industry partners.

- Development of novel steam cycles (Trilateral & Lorenz cycles)
- Three dimensional measurement of local frost structure
- Heat exchangers and gas-liquid separators, etc.

Two phase expander & demonstration unit for Trilateral steam cycle

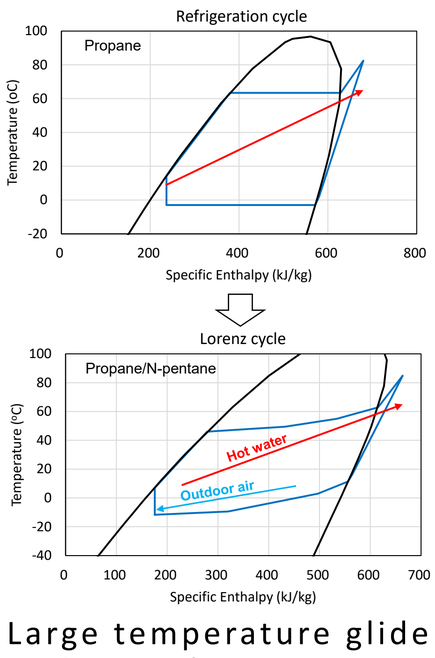


T_{wall} = -15℃, T_{air} = 7℃, RH = 45 %, V_{air} = 4.0 m/s

T_{wall} = -15℃, T_{air} = 7℃, RH = 85 %, V_{air} = 4.0 m/s

3D measurement of frost

High performance anti-scale V-fins



Large temperature glide Lorenz heat pump